APPENDIX D

CASE STUDY FOR HYDRAULIC TRANSIENTS

D-1. In a typical water pump station operating on suction level control, pump stop and restart occurs several times each day. Pump shutdown is the most common cause of hydraulic surge pressures or hydraulic transients in this type of system. Valve closure surges may be less frequent.

D-2. Figure D-1 illustrates a typical pressure/time history obtained at the pump discharge manifold of a pumping station following pump shutdown. As the pumps stop, flow into the pipeline drops rapidly; but the column of liquid in the line continues under its own momentum leaving behind a low pressure region. Eventually the momentum is overcome by the opposing force of static head which in turn accelerates the liquid column back towards the pumping station. The pump discharge check valves close in this interim period and a rapid pressure rise occurs when reverse flow impacts on the closed check valves approximately 6 seconds after pump shutdown.

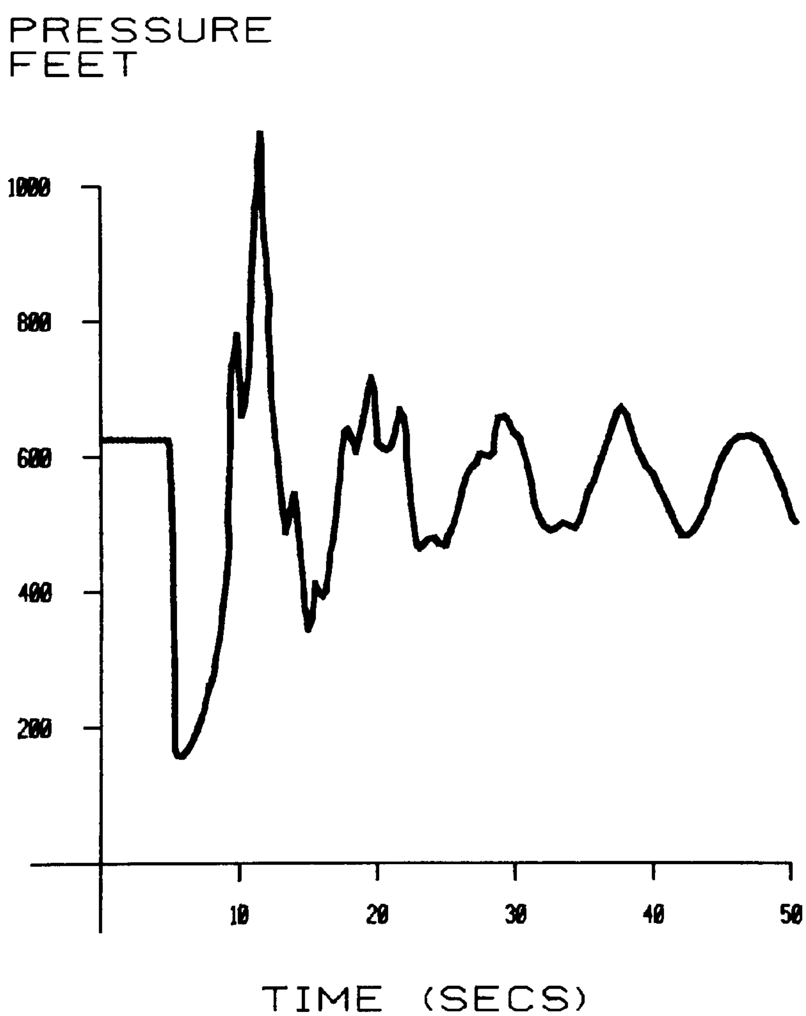

Figure D–1. Uncontrolled Surge.

D-3. The magnitude of the initial pressure drop and subsequent surge pressure is influenced by the initial pipeline velocity, the static head, the pipeline length, pressure pulse wavespeed, and friction. The system illustrated has over 550 feet (238 PSIG) static lift which produces the reverse accelerating head to cause a peak pressure of 1085 feet (470 PSIG). The peak pressure is attenuated to some degree by the action of air valves on the pipeline which opened when the initial pressure drop or downsurge traversed the system. This, together with the interaction of velocity changes in the pipeline, causes the inflections in the pressure history shown in the plot.

D-4. Figure D-2 illustrates the effectiveness of an air vessel or accumulator on the same system. Rapid velocity changes are prevented following pump shut down; instead water flows from the air vessel and the pipeline flowrate drops steadily. In turn, the pressure falls slowly and mass oscillation develops between the air vessel and the pipeline terminus.

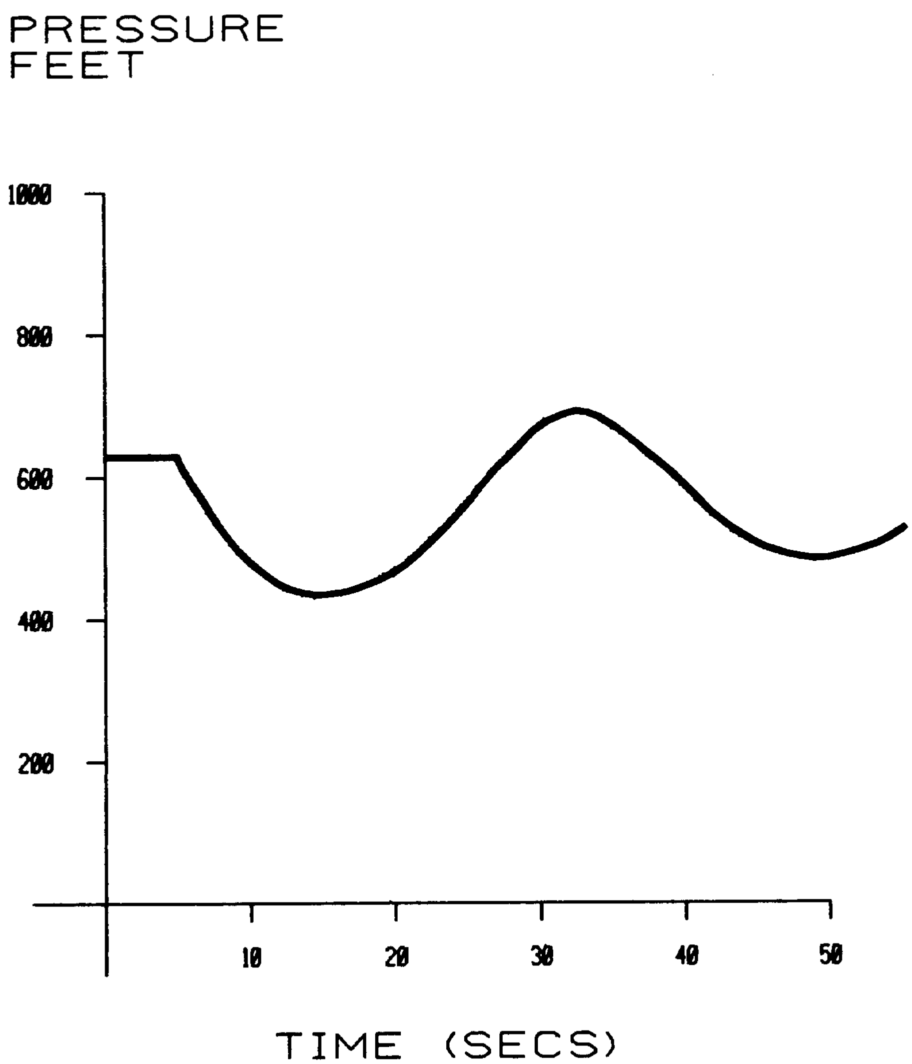

Figure D–2. With Air Vessel.

D-5. Alternatively, surge pressures may be reduced by provision of a pressure relief valve at the pumping station as illustrated in figure D-3. The initial effects of pump shutdown are unaltered but the relief valve opens as flow reverses towards the station. Flow impact on the closed check valves is therefore avoided and surge pressures are reduced to 637 feet (276 PSIG).

D-6. This case study illustrates the fact that an uncontrolled surge due to pump shutdown, in combination with an arbitrary factor of safety for the pipeline and check valve pressure ratings could cause system failure.

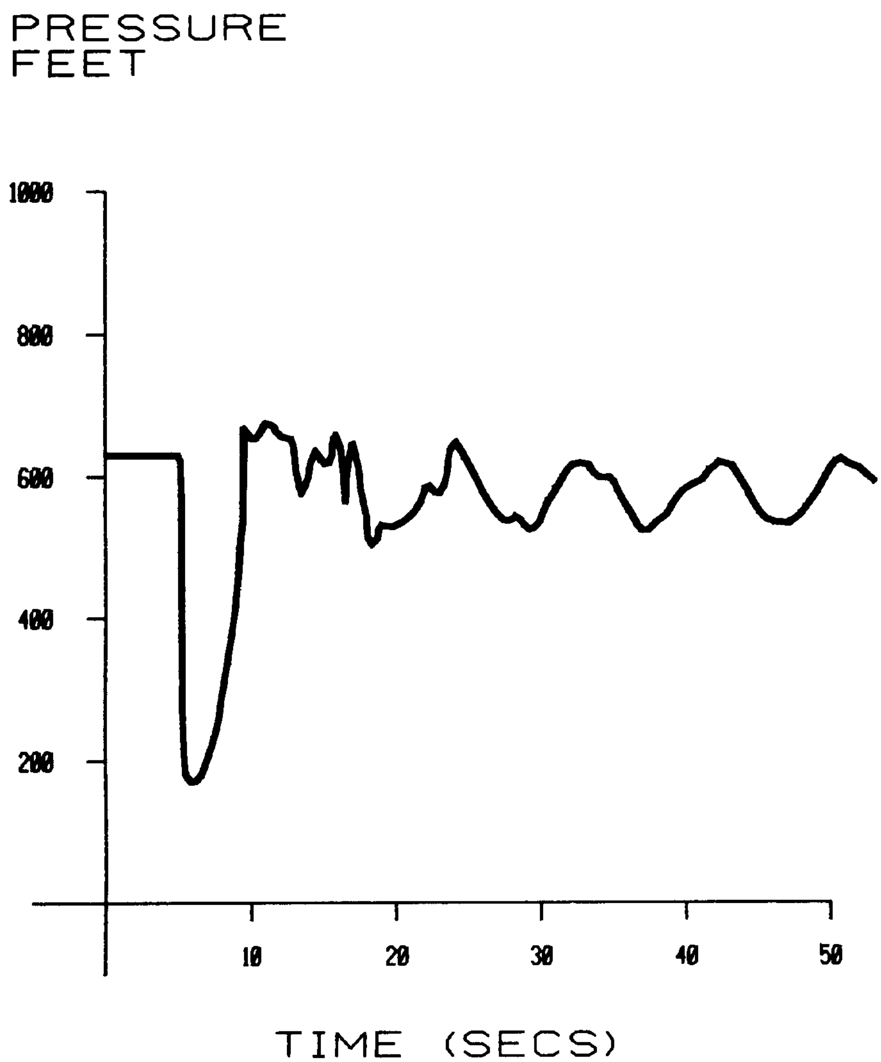

Figure D–3. With Pressure Relief Valve.